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OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • SUMMER 1985

Notable views of notable people on aerospace matters...

aerospace perspectives

Representative Jack Kemp *of New York, writing in The Washington Post:*

"(Its sponsors say) that their proposal for a 25 percent import surcharge is a shot across the bow of our trading partners. Like every shot across someone's bow, this one would miss its target. But it would score a direct hit on American businesses, workers and families. The Rostenkowski-Gephardt-Bentsen bill is no different in principle from the Smoot-Hawley tariff, which helped precipitate the Great Depression . . .

"To the degree that any American business could gain, it could only be at the expense of other American businesses—and, of course, American households. Both would be hit with price markups from foreign and domestic suppliers. American goods would cost more at home and abroad. Productivity and our standard of living would fall and we would lose jobs. Any reduction in our imports would be more than matched by loss of exports . . .

"In solving a problem, it helps to know that the problem is. Part of our trade deficit is not a problem. Countries that grow faster than the rest of the world, as we have done, generally import capital seeking a higher return, in the form of a trade deficit. This part of the trade deficit will automatically disappear if other countries pursue growth-oriented policies . . . But part of our trade deficit is a problem . . . Industries that export or compete with imports have been priced out of world markets by the dollar's rise. Just as the fall of the dollar in the 1970s provoked protectionism abroad, the rise of the dollar in the 1980s has led to calls for protectionism in the United States . . .

"The obvious answer is a monetary policy . . . that preserves a stable dollar. We need a domestic monetary policy geared to the value rather than the quantity of money. And we need to return to an international system of stable exchange rates that is neither inflationary nor deflationary. At the same time, we need a Reagan Round of talks on trade liberalization, patterned on the successful Kennedy Round of the 1960s."

Valeri Kubasov, *Soviet pilot-cosmonaut, in an article distributed by the USSR's Novosti Press Agency:*

"The Soviet Union and the United States of America have achieved great successes in carrying out their national space programs. But a pooling of their efforts would promise still broader prospects in the development of outer space for the benefit of all humanity. A good example showing that this is possible and useful is the Soyuz-Apollo flight 10 years ago in which I happened to participate . . .

"Cooperation between our countries in the field of space exploration and use continues now. The interplanetary probes launched by the USSR under the Halley's Comet Project carry instruments made in the United States. There is a cooperative effort in space biology. The satellites of the COSPAS/SARSAT system, for finding the whereabouts of ships and planes in distress, are being jointly used. But this level of cooperation cannot be regarded as satisfactory.

"Great prospects exist for combined work in outer space. A top priority would be the development of near-Earth space with the help of orbital stations. And, looking into the future, we would cooperate in organizing joint manned flights to the planets of the solar system, primarily Mars . . .

"Outer space belongs to all people, and it has to be developed together, hand in hand. Soviet cosmonauts consider the possibilities of cooperation only provided we have a peaceful outer space. Outer space must not be turned into an arena of rivalry and military confrontation. The U.S. Administration's Star Wars program will bring nothing to people but harm. A very dangerous situation currently exists in the field of space technology, but I hope that we will find a sensible way out of it which will lead not to a new round of the arms race but to a continuation of the work started by the Soyuz-Apollo flight."

General Lawrence A. Skantze, *Commander, Air Force Systems Command, in an address to the National Contract Management Association in Los Angeles, California:*

"In my 26 years in the acquisition business, I've never seen more public and political spotlights on the procurement process. I've also never seen so many ambitious and successful Defense Department initiatives to transform and reform contracting strategies . . .

"The entire federal procurement process remains a big public attraction for two major reasons: because it involves so much money and because there is so much official recorded information on almost every purchase. It's easier to get your arms around small buys—like DoD's spare parts—so publicity tends to focus on these. Critics also focus on isolated inefficiencies and abuses of these purchases . . .

"The public reacts to the horror stories, and so do their elected officials. Lost in the adverse publicity are major savings stories. From among many examples, I'll tick off just three recent successes: Competition sliced the production estimate for 10 Complementary Expendable Launch Vehicles. The initial government estimate was $2.5 billion; after we ran a competition we cut that by $440 million. Multiyear procurement of seven DSCS III satellites saved $140 million over annual buys. And using *should cost* pricing instead of historical price estimating saved $28 million on the reentry systems and vehicles contract for Peacekeeper.

"These represent business as usual and don't make headlines. As former Deputy Secretary of Defense Frank Carlucci recently observed, 'Chasing procurement scandals is fun and politically expedient—but it tends to distract us from the real issues.' The most important one, in my mind, is a procurement system that supports acquisition agencies in carrying out their missions."

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The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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CRISIS IN DEFENSE PROCUREMENT

By JOSEPH T. GORMAN
President and Chief Operating Officer, TRW Inc.

This guest editorial was excerpted from a speech by Mr. Gorman to the National Contract Management Association. Copies of the full text are available from the Office of Public Affairs, Aerospace Industries Association.

There exists what can fairly be called a "crisis in defense procurement." I refer, of course, to the outcry in Congress and the media against real and alleged misdeeds of the defense industry—a rising clamor replete with cartoons of cigar-smoking capitalists with dollar signs for eyes, rubbing their grimy hands as they peddle their $400 hammers and $7,000 coffee makers, and the ongoing or planned investigations of most of the country's leading defense contractors.

The problem is real; it is substantial and complex; and it demands thoughtful, objective and balanced responses from all involved with the process—and I emphasize *ALL*, in both the private and public sectors.

It would be more than a little presumptuous of me to suggest that I have all or even most of the answers, but I offer some thoughts that might be useful in general concept or approach as we involved with the business of defense respond to this crisis.

To me, a four-pronged approach makes the most sense—and indeed, perhaps it is the ony way we can hope for a reasonable measure of success, at least in the relatively near term.

First, we in the private sector must openly admit to some problems, openly vow to take whatever action is necessary to correct them, and clearly demonstrate that we are doing just that.

Second, our public sector customers and other constituents must take care to discharge their responsibilities along measured, prudent, rational and constructive lines within the constraints of current rules, carefully avoiding overreaction and action that will only exacerbate the problems and render success far more difficult or virtually impossible.

Third, customers and contractors must join forces in helping to avoid the promulgation of laws, policies, regulations and practices developed in response to the current environment that are inconsistent with or unsupportive of the achievement of our longer-range vision.

And fourth, as the current crisis begins to subside—which it surely will if we all do our part—customers and contractors must cooperatively and in appropriate ways work toward the kind of ultimate and more fundamental reform that will facilitate the attainment of our shared objectives.

There are elements of both short-term and long-term in this suggested approach. Both are critically important and short-term success is a vital condition precedent to long-term success. There are also elements of change implied by the concept—change on the part of most in both the private and public sectors.

More specifically, a "business as usual" approach on the part of contractors will not work; both attitudinal and behavioral changes are necessary in order to correct the real and perceived problems.

Moreover, the same sort of change is also necessary on the part of customers and other government constituents. Attitudes and behavior that result in overreaction, personal and institutional self-interest, and "protect my flank" practices must give way to balanced and constructive approaches. Confrontation and adversarialism must yield to more effective two-way communication and teamwork aimed at the common good.

Successful resolution of the crisis will require a substantial and sustained effort by all of us. Nothing less, in my view, will enable us to meet the balanced best interests of all our many constituent groups, and particularly the best interests of the public at large.

AUTOMATION IN AEROSPACE MANUFACTURING

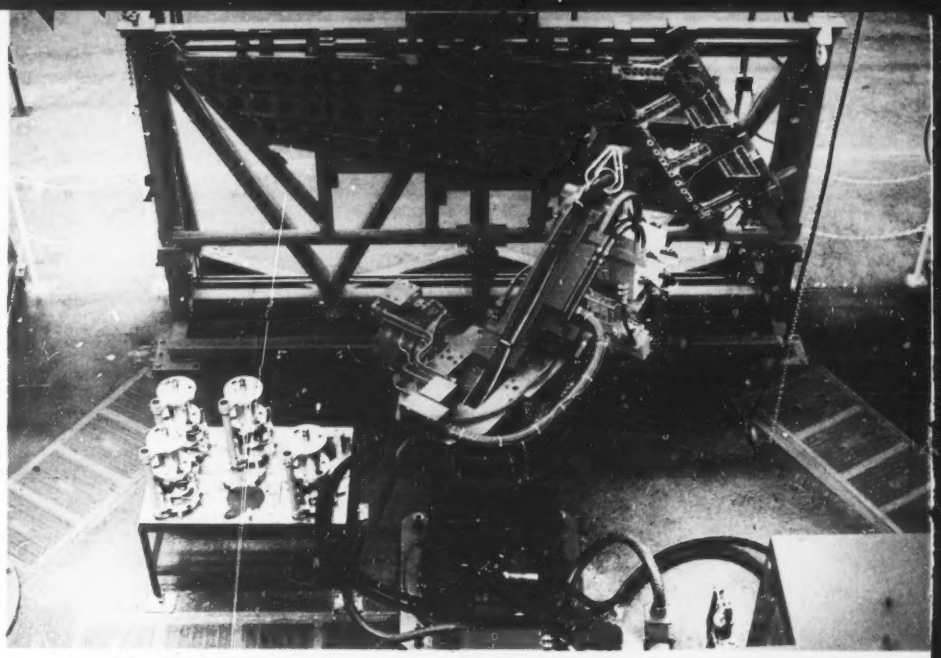
By JAMES J. HAGGERTY

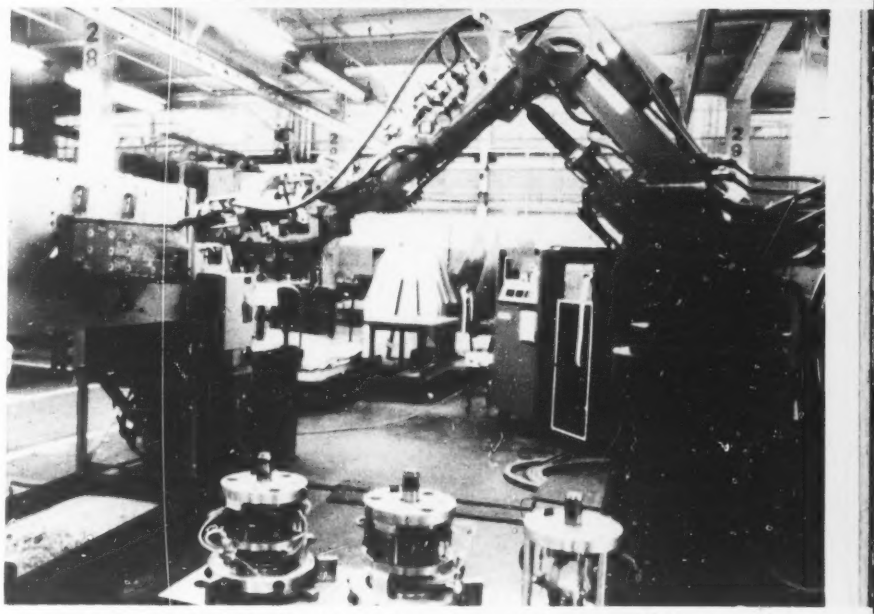
Robotics research is building a technology base for the aerospace factory of the future

For a long time, it was accepted as a fact of aerospace life that a new system would inevitably cost more than its predecessor. Naturally, the new system must do the job better or there would be no reason for developing it. Because the predecessor system was itself a technologically advanced product, making the new one better involves extensive development of even more advanced technology—and that, in turn, generally results in a more complex system, more difficult to produce, more demanding of labor hours and more challenging to the manufacturer's prime goals of maximum quality at minimum cost.

Today, however, there is a growing belief that future aerospace systems need not cost more; in fact, they may cost substantially less if a number of new manufacturing technologies now in development successfully translate to the factory floor. Government agencies and aerospace companies, working in some cases cooperatively and in others independently, are conducting extensive research and development toward the automated, superefficient "factory of the future." Early results of this effort suggest that such a facility is entirely feasible and capable of providing large-scale cost reductions, along with bonuses in improved product quality and shorter production time.

Research on manufacturing technology is getting as much attention today as product research. Manufacturing laboratories examine new designs, well in advance of the system's release to the production floor, with an eye to finding new manufacturing techniques that lower cost, speed production, enhance quality and improve the "yield," the output of acceptable-quality items produced the



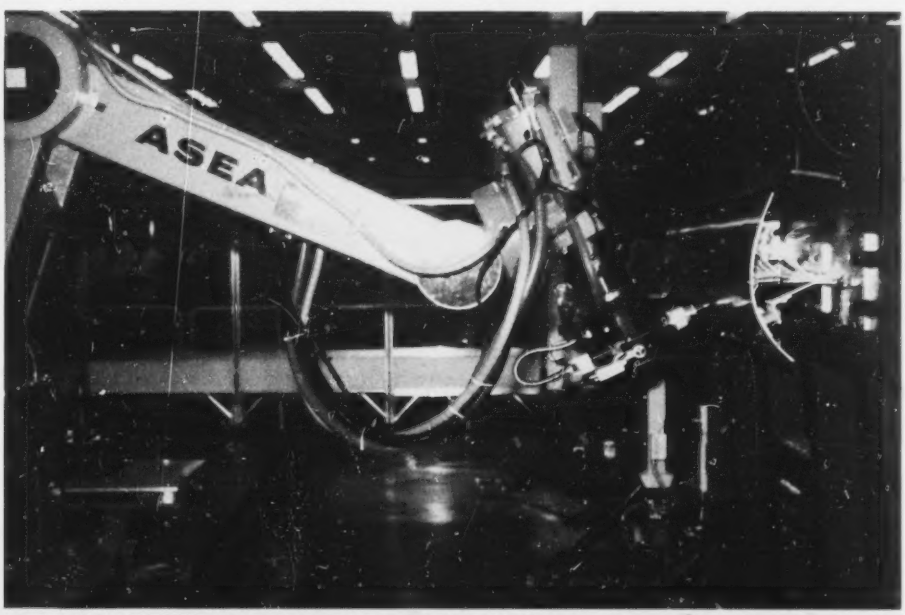


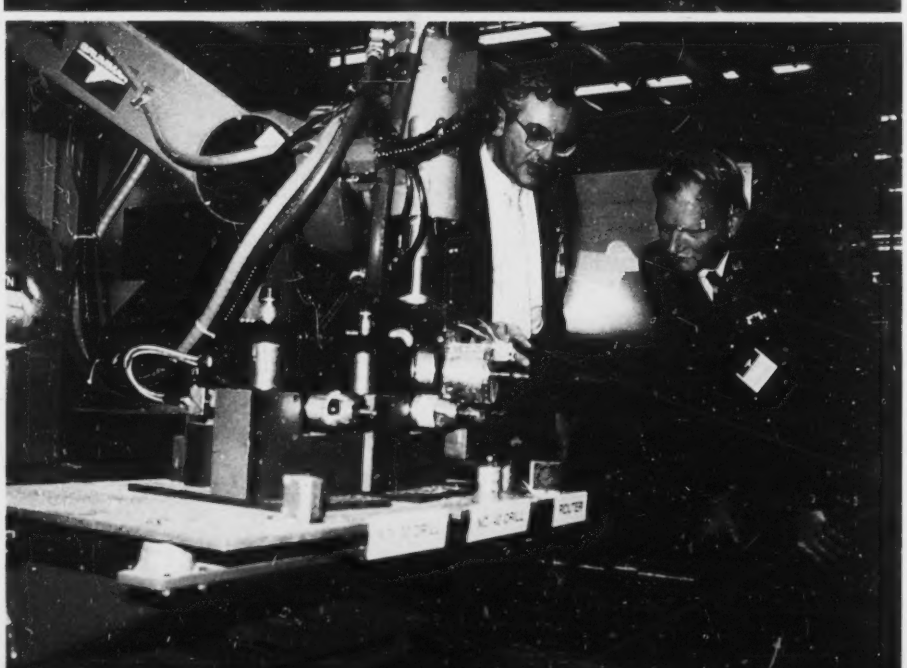
Robot systems at General Dynamics' Fort Worth plant. A General Dynamics/Air Force robotics demonstrations program proved that robots are cost effective and productivity enhancing in drilling and routing sheet metal parts on the company's F-16 assembly line

first time through the manufacturing process. Most of the new techniques being employed and being explored involve robotics and other automated operations; for the most part, they are still in R&D status but they are regularly demonstrating their exceptional potential for increasing manufacturing productivity. The fully-automated factory is still years down the road, but recent research in automation has provided convincing evidence that it is not as distant a prospect as it was considered at the start of this decade.

Representative of many industry/government manufacturing technology programs is the robotics/automation research and development effort sponsored by the Air Force Systems Command (AFSC). This work involves two separate but related programs with common goals: improving productivity, lowering cost and reducing lead times in acquiring hardware from contractors. One program, conducted by the Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio, focuses on introducing robotic assembly techniques to military aircraft production. The other, conducted by AFSC's Electronics Systems Division at Hanscom Air Force Base, Massachusetts, is an incentive program designed to stimulate contractor investment in advanced robotic and automated equipment for assembling electronic systems. Both programs involve cost-sharing participation by a number of aerospace manufacturers.

This Gruniman Aerospace robot system is demonstrating its ability to perform precision drilling on parts for a fighter aircraft. The closeup view shows the "end effector," the working end of the system. The robot can use several different types of end effectors – drillers, routers, riveters, etc. They are placed on the robot platform in such a manner that the robot can select, pick up and attach the appropriate tool for a specific job.





Aeronautical Systems Division

Aeronautical Systems Division (ASD) is managing a variety of robotics research and development projects, some of them intended for near-future factory floor applications. ASD's intent is to broaden the manufacturing technology base and "fill the technical pipeline for future manufacturing." Under the guidance of ASD's Manufacturing Technology Division, these robotics projects combine new computer, microelectronics, process science and artificial intelligence technologies toward development of building blocks for a future automated manufacturing capability. In addition to cost and lead time reductions, says ASD, such a facility would not only produce parts of better quality, but it would be capable of better quality control and would be better able to handle "surge"—sharply stepped-up production—should an emergency require.

Robotics in Aircraft Assembly

Initiated in the latter 1970s, ASD's initial efforts in factory robotics research began proving out in the early 1980s with successful demonstrations at plants of General Dynamics Corporation, McDonnell Douglas Corporation and Northrop Corporation.

In 1980, a General Dynamics program proved that use of robots for drilling and routing sheet metal parts in assembly of the USAF F-16 fighter was both cost-effective and productivity-enhancing. General Dynamics reported production increases of four-to-one over the manual method of drilling and routing.

Also in 1980, the USAF and McDonnell Douglas unveiled a robot with a high degree of flexibility. The robot is part of a "work cell" that includes an automated riveter, a materials conveyor and a high resolution vision system. Microprocessors control the individual elements of the work cell and communicate with a larger computer that controls and coordinates the entire cell in drilling and riveting aluminum sheet metal parts.

In a third successful demonstration in 1980, Northrop Corporation used a robot to assist in manufacture of graphite composite aircraft components. Part of a flexible automation center, the robot

was employed in certain "lay-up" operations—such as picking up, orienting and transferring materials—and it was able to reduce lay-up time by two-thirds.

A major development of the 1980s is MCL (Manufacturing Control Language), used to program robotic systems and supporting computers. Initially developed by McDonnell Douglas, MCL has been refined in recent years to make it easier to adapt to a variety of computer systems and to allow its use with all elements of a robotic work cell. With MCL, a robot can be programmed to handle a great many shop jobs; for example, the same robot can position parts, spray paint or arc weld.

Composite Materials Programs

Use of composite materials in aircraft manufacture is expanding rapidly. Composites offer high strength at light weight, hence have potential for dramatic increases in aircraft performance—but they also complicate the production job because shaping and assembling composite components is labor intensive, time consuming and costly. Looking to automated operations to cut the time and cost of working these hard to handle materials, the Air Force is conducting a manufacturing technology program called CASPIN (Composite Assembly Production Integration).

In earlier work on automated production of composite parts, robots were employed in supporting roles, for lay-up operations. Under CASPIN, ASD is taking automatic manufacture of composite structures a step further, to use of robotics and other computer-controlled equipment in actual assembly of aircraft components. One CASPIN contractor—Grumman Aerospace Corporation—has successfully demonstrated an Integrated Mobile Robotic Assembly Cell in which a rail-mounted robot performs such assembly functions as drilling, hole inspection, fastener installation, grinding and flushness inspection. Grumman has also demonstrated robot technology in assembly of a very complex engine inlet duct structure made of composite materials. Northrop, the other CASPIN contractor, is developing a capability—to be demonstrated next year—for full robotic assembly of composite components.

In other areas of robotics technology, McDonnell Douglas and ASD are developing a complete manufacturing cell—including robot, processing equipment and sensors—for automated aircraft windshield canopy drilling. Windshield drilling was selected because, handled manually, it is a singularly labor intensive operation. The canopies are made of polycarbonate material that is very hard to drill. Repetitive drilling with a heavy tool induces worker fatigue and the coolant used in drill motors contributes to a poor working environment. Robotic drilling will alleviate the employee-related problems, reduce programming and drilling time and provide quality improvements, because it will allow use of heavier, more rigid and more efficient drilling motors than can be handled by humans. It is planned to use the robotic system in actual production of the USAF F-16 fighter, the Navy F-18 shipboard fighter and the AV-8B vertical lift aircraft.

Another company—Robotic Vision Systems, Inc.—recently demonstrated, under ASD contract, an extremely accurate advanced three-dimensional vision system for robots. For the demonstration, the company selected drilling tasks, but the vision system is applicable to a wide range of assembly operations. Designed to compensate for robot inaccuracies or programming errors, the vision sensor can be mounted on the end of a robot arm or placed near a workpiece in a fixed position. The sensor is able to gather and interpret position and orientation data directly from the workpiece and feed this information to the robot controller. This allows the robot to know where it is relative to the workpiece and maintain a high degree of accuracy—within five thousandths of an inch in the drilling demonstration.

Another example of progress in robotics is Grumman Aerospace Corporation's demonstration of a robotic system for accurate automated drilling and routing without the aid of a guiding template. Now in use on Grumman's manufacturing floor, the system consists of four work cells and a robotic arm on a 20-foot track; the robot travels along the track from cell to cell to perform its work, staying in almost constant use as long as the cells are "loaded" with workpieces. Initially demonstrated for drilling sheet metal parts, the robot is a flexible system that can also be used for riveting, assembly, welding and a number of other manufacturing operations.

Advanced Robotics Research

Under ASD's Manufacturing Science Program, the Air Force and industry are working on a number of cost-sharing projects designed to expand the utility of robotic systems. A major technology advancement program involves development of a system capable of automatically performing a complete range of aircraft

An Air Force officer is examining an advanced vision system that incorporates a camera and an accuracy module. Developed by Robotic Vision Systems, under contract with the USAF's Aeronautical Systems Division, the unit compensates for robot inaccuracies and programming errors, thus offers exceptional precision that allows robots to perform more complex tasks.

A part of the Westinghouse Electronic Assembly Plant at College Station, Texas, a highly automated manufacturing center developed as a joint company/USAF venture.

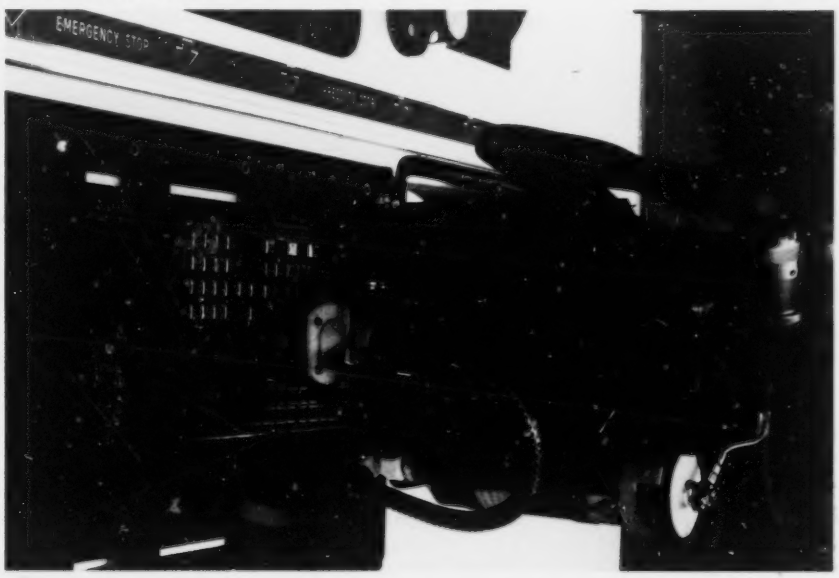
assembly operations and of handling all typical aircraft materials, including aluminum, titanium and composites. Goal of this program, says ASD, is to overcome the lack of flexibility and adaptability that have so far been the major roadblocks to automated aircraft assembly. Attainment of the goal would mean large-scale cost reductions, because assembly comprises 40 to 60 percent of the total production cost of a modern military aircraft.

Two development teams, each composed of five companies, are working on parallel approaches to the flexible automated assembly system; one is headed by Rohr Industries, Inc., the other by Grumman Aerospace.

Two other teams are concentrating on building block technologies essential to development of flexible assembly systems. A team headed by Honeywell Inc. is focusing on advancements in sensors and integration of vision and force control. A second team, headed by Martin Marietta Denver Aerospace, is working toward a demonstration of automated dimensional inspection of aircraft components; the system will include two robots, a scanning laser ranging system and a variety of other dimensional measurement tools, such as vision, bore gauges and ultrasonic probes.

These R&D programs—the automated flexible assembly system and the building blocks technology development effort--are intended to pave the way for a major automated assembly center to demonstrate robotic airframe assembly as an integrated system. ASD hopes to let a contract for such a center in 1987.

At the Electronic Assembly plant, robots like this one load, assemble and test "flat packs," containers of integrated circuits that are mounted on printed circuit boards.



Electronic Systems Division

In the area of defense electronics, an automated manufacturing center already exists. It is Westinghouse Electric Corporation's Electronic Assembly Plant (EAP), located in College Station, Texas. Opened in 1983, the EAP employs a variety of computerized robot-based manufacturing equipment designed for the particular needs of the defense electronics industry, whose work is characterized by a broad mix of items produced in small lots with a high change rate and exceptionally demanding quality requirements. The plant is a joint Air Force-Westinghouse venture, the product of a pioneering manufacturing technology program developed by the Air Force Systems Command's Electronic Systems Division (ESD).

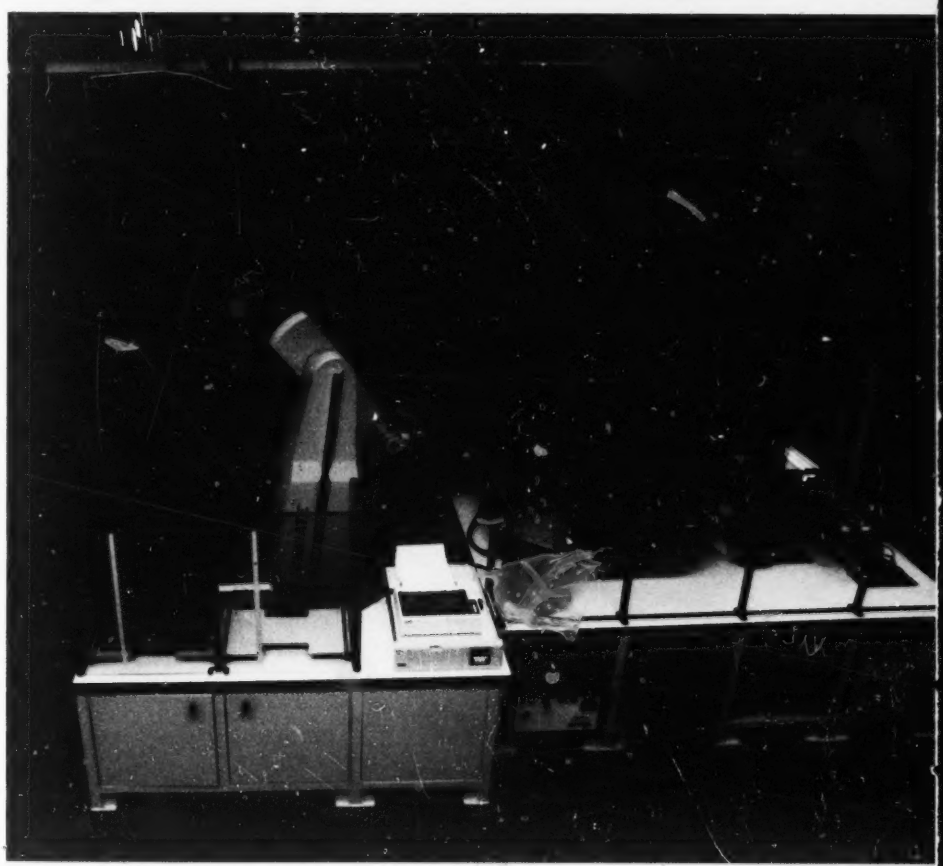
An expansion of other Air Force efforts to stimulate aerospace factory modernization, the ESD program is called

GET PRICE. The latter word is an acronym for Productivity Realized through Incentivizing Contractor Efficiency. What that means is that GET PRICE is a program designed to lower the cost of electronics equipment to the military services through plant modernizations financed on a government/industry cost-sharing basis—and the contractor's incentive is that he will share in the savings resulting from the installation of more efficient manufacturing systems.

In the defense industry, plant modernization has not progressed as rapidly as the Department of Defense would like. One reason is that there is considerable risk in committing to a long term modernization program to build a product for which the government contracts on a short term basis, usually one year at a time. Production programs are subject to frequent reviews and cancellations or program reductions are not uncommon. When that happens, the contractor who has modernized finds himself with an expensive new facility designed expressly for a product the government no longer wants or one being produced in uneconomic quantities. Another reason is the traditional government determination of "reasonableness of profit" paid to its contractor; for the most part, it has been based on cost factors, so the more cost is reduced the lower the profit. Thus, a contractor who invests in more efficient modern plant and equipment that allows significant cost reductions is likely to find that his investment has reduced his profits.

GET PRICE offers an answer to these "negative incentives." Under this program, contractors are rewarded—by increased profits realized through shared savings—for reducing product cost to the government through the application of advanced manufacturing technology. Risk is also reduced because the government usually contributes part of the funding for the design and demonstration of a modernization initiative. A GET PRICE contractual agreement spells out the requisite contractor modernization investment, the government contribution, the estimated savings and how the savings will be shared.

In the Westinghouse EAP at College Station, the first application of GET PRICE, the parent Westinghouse Defense and Electronics Center is investing some $55 million in the plant and its robotic systems while ESD funding totals $6.7 million. The EAP features three major GET PRICE-sponsored systems for automating production of Westinghouse electronic equipment for the Air Force.

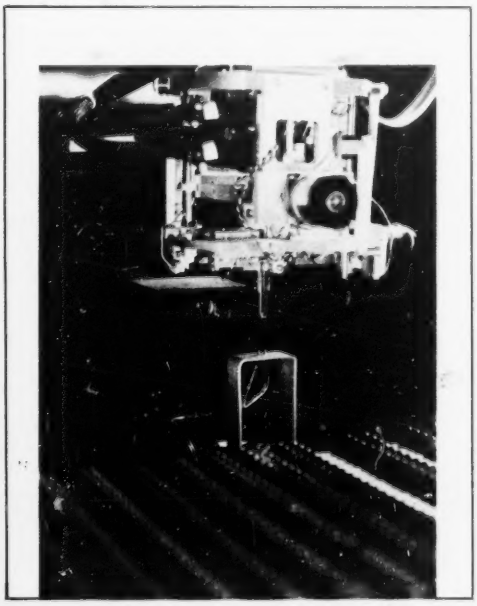


Two of the GET PRICE developments are used in manufacture of complex printed wiring assemblies, or printed circuit boards. One called MARK (Material Accountability Robotic Kitting System), sorts out the various components for each circuit board, loads them into containers (kits) and positions the kits in a carousel for assembly. The second GET

Major General Brien D. Ward, vice commander of the USAF's Electronic Systems Division, inspects a Westinghouse harness produced automatically by a robot system.

Called MARK, this robot system sorts out components for a printed circuit board, loads them into kits and positions the kits in a carousel for later pickup and assembly.

Another of the Electronic Assembly Plant robotics systems, the Axial/Radial/Can Assembly Work Cell, automatically assembles a densely packed wiring assembly; it positions, cuts, inserts and clinches the variously sized components to produce a complete printed circuit board.



PRICE development, the Standard Electronics Assembly System, is a series of work cells for automated assembly, soldering, testing and inspection of printed circuits. The third major GET PRICE system, called REACH (Robot-Enabled Assembly of Cables and Harnesses) is self-descriptive. The advanced EAP facility contains a great many other automated systems independently developed by the Westinghouse Manufacturing Systems and Technology Center, an industry leader in manufacturing productivity research; there will probably also be additional GET PRICE-sponsored advancements for automated production at EAP.

The EAP is already regarded, by both Westinghouse and the USAF, as an outstanding success story. Today, more than 85 percent of the printed circuit boards are successfully assembled the first time through the process; this compares with 12 percent five years ago, when the boards were manually assembled at another plant. Cycle time has been reduced from 12 weeks to four. Cost reductions of 44 percent have been achieved. By 1987, Westinghouse estimates the process yield (first-time-through successful assembly) at 95 percent, cycle time at two weeks and overall cost reductions of 60 percent. Air Force Systems Command estimates that savings on defense equipment produced at this facility over the next 10 years may reach $1 billion.

If that happens, the USAF will win a major battle in its "war on costs" and get a bonus in improved product quality. Westinghouse, through its share of the savings, will more than recover its investment and, having demonstrated its increased productivity, will improve its prospects for future Air Force business. And GET PRICE offers something extra for both government and industry, says ESD: "It is (the) intent to provide a framework for abolishing the adversarial relationship that has existed between the services and the defense industry in the past, and open the door to new and cooperative efforts that will benefit both parties."

Other GET PRICE Projects

The Westinghouse EAP is the most dramatic example of what GET PRICE can do to improve industrial productivity and quality. There are several other GET PRICE programs, none as far along as the EAP, but they have impressive savings potential and they are advancing automated manufacturing into a number of new areas.

General Electric Company built an automated machining center in Syracuse, New York to assist in production of electronics equipment for three Air Force programs.

Rockwell International Corporation's Collins' Divisions group is working on four projects. Two of them focus on automating certain electronics assembly operations that are currently labor intensive; another is an automatic system for improving quality control and the fourth is a project to facilitate the integration of design and manufacturing data.

Hazeltine Corporation is developing three automated work centers, one for printed circuit board assembly, one for improving product quality and lower production costs, and a third that integrates factory storage and distribution systems.

The Singer Company's Kearfott Division also has three GET PRICE projects. One involves development of an automated module for parts inspection and test; another will provide an integrated work center for automatic placement of electronic subassemblies; and a third is designed to improve quality control of electronic circuit elements supplied by vendors.

These latter four companies will invest a combined $18.5 million in robotic systems and other facility modernizations. ESD will supply $11.4 million for design and demonstration. ESD estimates that these investments will generate savings of about $226 million. GET PRICE is still in an early stage of development, but initial work shows that the projected savings are real and the program is inspiring broad interest among defense contractors. A number of them have expressed interest in adapting some of the automated stations at the Westinghouse EAP to their own operations; more than a dozen others are discussing with ESD proposals for new GET PRICE initiatives.

"The bottom line of the GET PRICE program," says ESD, "is that by encouraging defense contractors to make capital improvements, the Air Force will receive lower prices on its production programs and product quality will be improved, thus assuring a stronger defense posture. This program has potential applicability across the entire defense business and, once shown to work successfully on Air Force programs, ESD plans to expand GET PRICE to include Army and Navy programs, as applicable, at various defense contractors' facilities."

THE

By
Dr. ALLEN E. PUCKETT

Chairman of the Board
and Chief Executive Officer,
Hughes Aircraft Company

It is a critical time in the history of American industry. It is not this month or this year that is particularly critical, but probably the entire decade of the 1980s and into the '90s. These may be the years that decide whether U.S. industry will retain leadership in the world of industrial nations.

Highly motivated people, both in Europe and the Far East, are dedicated to creating a competitive industrial base. In most cases their effort is really a part of a national program. And the results are showing.

In 1984 our international trade balance showed a deficit in excess of $100 billion. In 1985, it will be substantially greater than that. Clearly, we can't allow this trend to continue if we want to maintain our comfortable standard of living and our national economic health. We can't continue to buy products we didn't make with dollars we didn't earn.

Out of all this concern has emerged a new public interest in three words—productivity, quality, and excellence. In my vocabulary, these are the new buzz words. They are closely related. It is difficult to talk about any one without talking about all three. And those three words, taken together, are the key to retaining leadership in American industry. The question is how do we achieve improvement in all three?

Let's start with productivity. We can expect to achieve improved productivity in three ways: the use of improved technology in our products, increased investment in more efficient machinery, tools and equipment, and, finally, the creation of a skilled and motivated work force.

The first method has an appealing ring. By using more advanced technology in our products, we should be able to achieve the same end result with less effort. The most spectacular examples are in the world of electronics, where a single little chip of silicon can do the work of many hundreds or thousands of separate components. Therefore we can build a device, like a radio or a computer, that will outperform its ancestor by many factors but is far easier and cheaper to manufacture and assemble. So, it's very attractive to lean on technology as an easy way to better productivity. That shouldn't take much effort—just a little ingenuity and invention.

The second method—investing in more efficient tools, machinery and equipment—is also appealing. We think of robots that can perform repetitive tasks without error and with blinding speed. They don't eat, drink, take time off, and they don't have any bad habits. So that term "robotics" has become the catchall in the public mind for increasing productivity in any and every phase of manufacturing. In fact, robotics is not a very good word to describe the enormous opportunities that exist for automating all sorts of functions—from the office, to the engineering department, to fabrication and assembly operations and, of course, to performing test functions. "Automation" is the right word, and automation is indeed a very powerful tool.

These two methods of increasing productivity seem to have captured most of the public attention. They are particularly attractive because they seem to be do-able without disturbing our comfortable way of life. We just focus on innovation and spend a little money. It would be nice if that would solve our productivity problems. In my opinion, these methods are important—but taken alone, they are a long way from doing the job.

Of the three methods, I believe the

PEOPLE FACTOR

third—creating the skilled and motivated work force—is by far the most important. That is the people factor. We can have the most modern and technically advanced products, and the best automated tooling, but without the people factor—the skilled and motivated work force—we have no chance of making dramatic improvements in productivity.

The term "work force" must include everyone from the top to the bottom of the organization—from upper management to the assembly workers on the production line. You can't create skilled and motivated assembly line workers without skilled and motivated top management.

This method is also probably the most difficult. It will require that we change some very traditional ways of viewing our jobs and our employees' jobs. It will require some cultural changes. It will require some changes in management style and particularly in management-employee relations. And it will require a substantial amount of hard, personal effort on the part of everyone.

What is it that we must do? We want to motivate our employees—to do what? Is it simply to work faster—to process more pieces of paper or assemble more widgets per hour?

Here is where the concept of quality enters the picture. In essence, we want everyone—all of us—to perform our jobs with greater concern for the quality of the result. Quality is the key—we cannot have improved productivity without improved quality in every step of the process. And improved quality depends, in the end, on people.

What do we mean by quality? If you look up quality in the dictionary, it says, among other things, "degree or grade of excellence"—and there we have the third key word—excellence. Achieving a particular level of quality means achieving a particular degree of excellence.

This suggests a more quantitative way of viewing quality—we may set standards of performance, and we may require adherence to those standards, and measure performance against those standards. Adherence to standards requires discipline—a clear perception that there is a right way and a wrong way to do anything. Discipline at every step of the complex manufacturing process is the most powerful tool we have to ensure quality at the end, and at the same time to minimize the cost of getting there. It is the only way to be certain that quality is built in—and not inspected in.

There is a special feature of quality that we should note with particular attention: the standards by which we judge quality are not absolute values, they are very dynamic and they change with time. At any moment, we may set standards that are the best that we think we can do at that moment. At a later time we—or our industrial competitors—find that we can really do much better. If we are truly concerned about maintaining a level of excellence that will compete successfully in this modern industrial world, then we must be prepared to update our standards on a continuing basis.

How do we motivate people to strive for quality in their work? How do we cause them to respect and adhere to the standards we establish?

Perhaps the most powerful motivating factor for any individual is the feeling of personal involvement in the task at hand, and the feeling of personal responsibility for the result. Personal involvement means taking part in defining the objectives of the job. It means helping to establish the standards by which quality is judged. It means being a part of the process.

It means having an opportunity to influence what is going on, or the way it is done. It means having a chance to speak up, and to have someone listen. It means believing that your opinion is important. It means having a chance to make what you think is the best use of your own abilities and talents. It means having pride and self-esteem in your own performance.

There are many techniques for increasing this personal involvement. Generally speaking, all the techniques come under the heading of "improved communication." Improved communication means not only from the top down, but from the bottom up. It means better human relations in the organization, better understanding of each individual—of his abilities and aspirations and what turns him on.

What does all this have to do with productivity? The connection is that people who are concerned with excellence in their work are by definition dedicated to minimizing mistakes and avoiding unproductive efforts. They are focused on achieving a certain goal—a clearly understood goal—in the most efficient way. They do it right the first time. That means they do not have to do it over again a second and a third time. And they are constantly searching for ways to do it better.

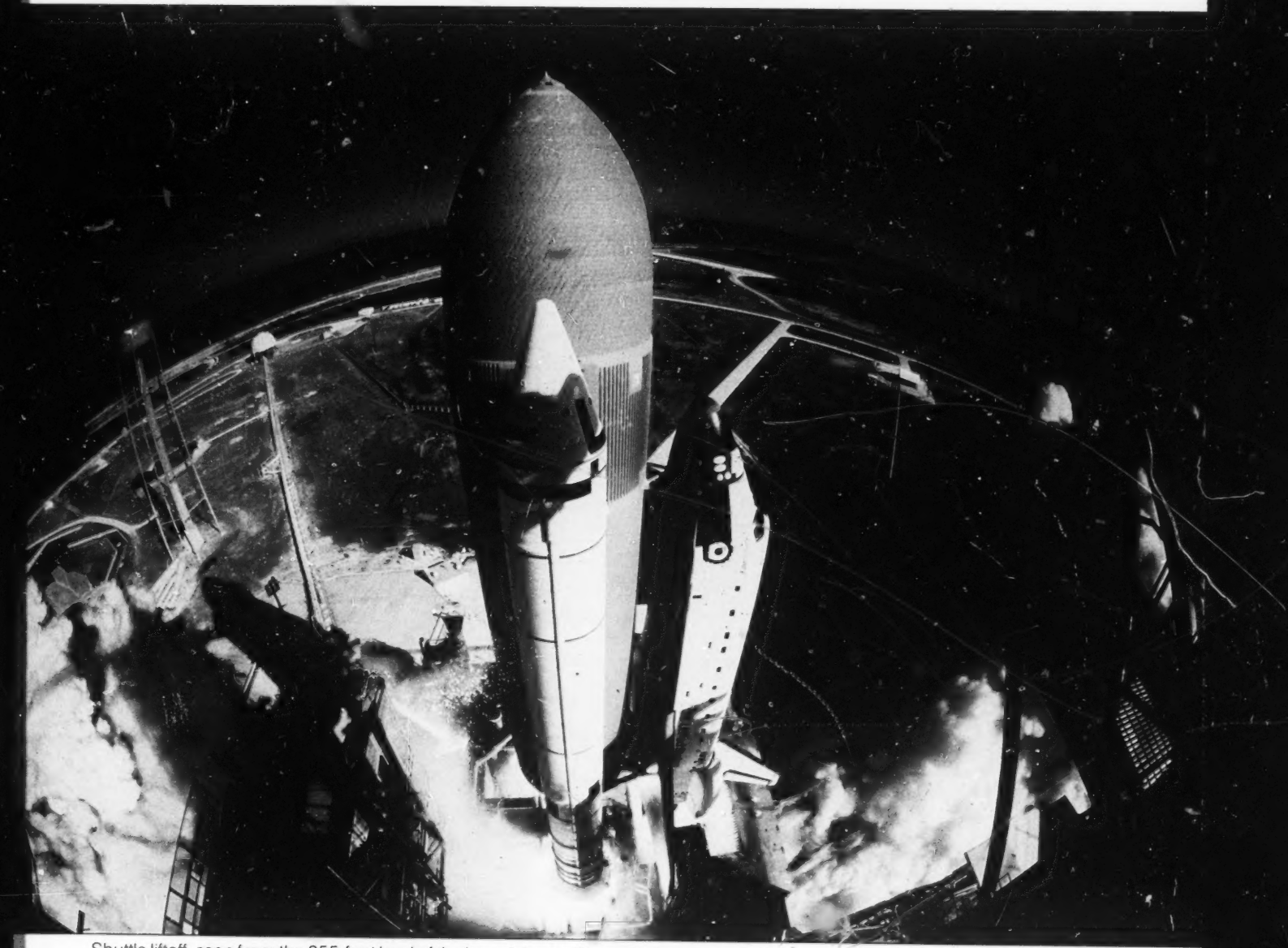
The fact is that it usually isn't any more difficult or any more expensive to do something right instead of doing it wrong. The only cost is in personal dedication and determination—the deep commitment to do it right.

We have now set ourselves a very interesting and difficult problem. We want our employees—including ourselves—to make a personal commitment to quality. We want them to accept a rigorous discipline in their work, and to respect the standards that they have helped to establish.

At the same time we recognize the need for continuous change and improvement in the way we do our jobs. We must not become locked into a routine that by its nature is so rigid that it discourages or inhibits new and innovative thinking. On the one hand, we want unwavering obedience to a current procedure, and at the same time a restless impatience to find a better one. Not an easy job! The only answer to this sticky problem is to provide real leadership in management.

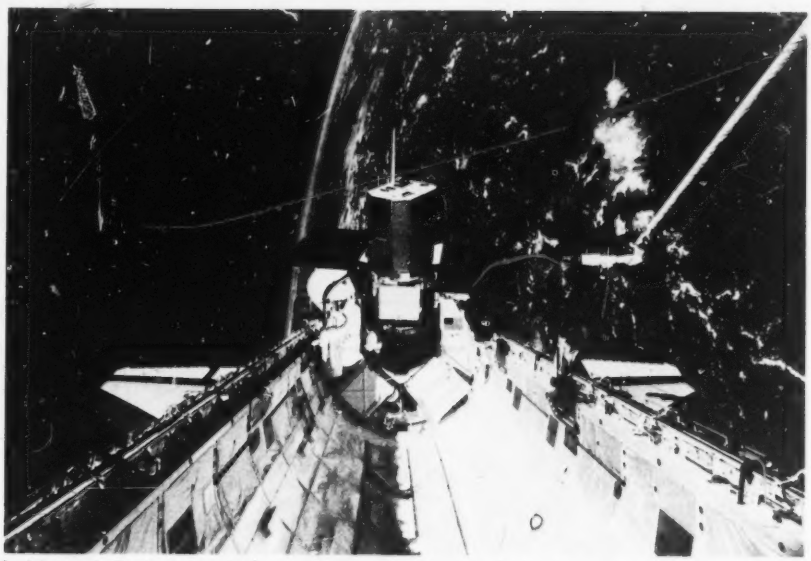
This country has all the tools and all the resources that are necessary to preserve our leadership and our comfortable standard of living in this very competitive world and, above all, we have the sort of people with the spirit and outlook on life that can achieve this third leg on the productivity stool. It's these people we depend on for the future of this country. All we need to do is to be more industrious, efficient, and ingenious in the way we use them.

This article is an excerpted version of Dr. Puckett's address to the International Industrial Engineering Conference in Los Angeles, California

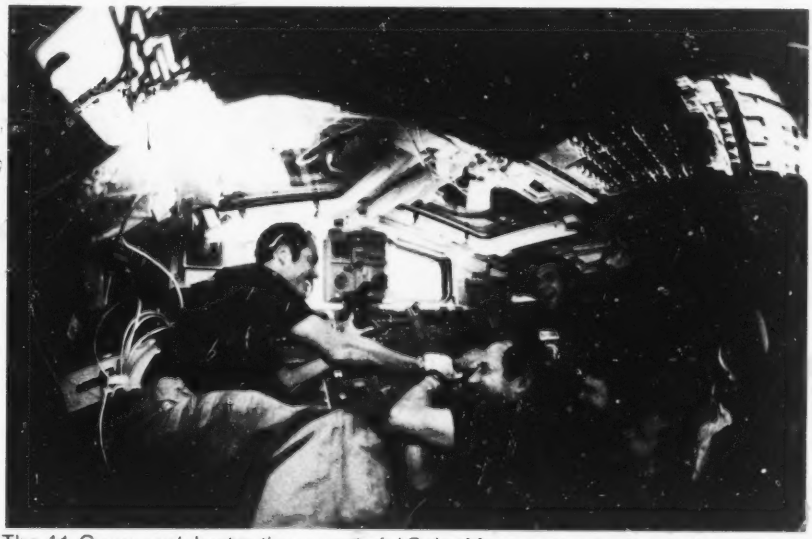


Shuttle liftoff, seen from the 255-foot level of the launch tower. The entire launch pad is visible to the wide-angle IMAX camera, housed in a specially-engineered firebox.

THE NEXT BEST



In history's first retrieval of an orbiting satellite, the Solar Max spacecraft is berthed in the Orbiter *Challenger's* cargo bay on Flight 41-C.



The 41-C crew celebrates the successful Solar Max capture and redeployment.

THING TO BEING THERE

One enterprising company has a plan afoot to offer commercial trips into orbit aboard the Space Shuttle or a similar passenger-carrying vehicle. But the four Shuttle Orbiters are going to be very busy for the rest of this century and the similar vehicles contemplated are still on the drawing board. So don't count on an orbitour until the 21st century is well past its infancy.

In the meantime, however, you'll have an opportunity to experience the excitement of space flight by viewing *The Dream Is Alive*, a stunning "spacetacular" featuring Shuttle in-flight footage displayed in giant screen IMAX® format, a high fidelity motion picture system that presents an image 10 times larger than conventional 35 millimeter film.

Projected onto a screen five stories high and seven wide, *The Dream Is Alive* puts the viewer into the Shuttle Orbiter to tingle to the thundering roar of a lift-off, observe the brilliance of a sunrise undiluted by atmosphere and watch from ringside as the astronauts work inside and outside the spacecraft. It is, says producer Graeme Ferguson, president of IMAX Systems Corporation, "the next best thing to being there." Agreement was unanimous among those who witnessed a preview.

The Dream Is Alive was first publicly exhibited at a June premiere in the Smithsonian Institution's National Air and Space Museum (NASM) in Washington, D.C. It is now being shown regularly at NASM's Samuel P. Langley Theater. But you won't have to visit Washington to see the film; it is scheduled to open in more than 40 IMAX and OMNIMAX® theaters in 1985 and 1986.

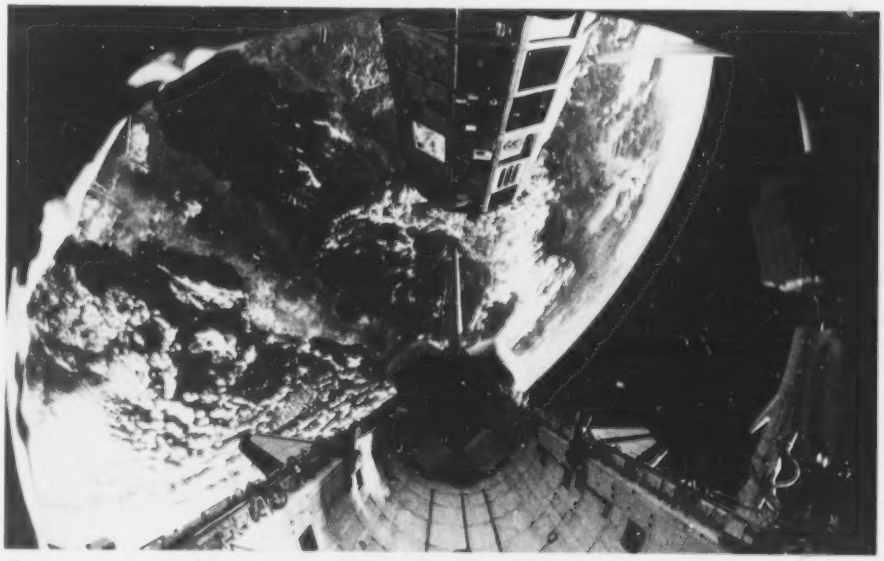
The Dream Is Alive is the fourth film in

the IMAX format to be presented at NASM. There was also an earlier show about the Shuttle called *Hail Columbia*, which had no space footage and only half its scenes in IMAX. It prompted NASM director Walter J. Boyne to request NASA support for a new IMAX film that would include space footage, and NASA Administrator James E. Beggs responded favorably. NASM then enlisted Lockheed Corporation, NASA's contractor for Shuttle ground processing, as corporate sponsor. Lockheed and NASM jointly underwrote the $3.6 million budget and contracted with Threshold Corporation—a U.S. subsidiary of the Canadian IMAX Systems Corporation—to produce *The Dream Is Alive*.

An interesting facet of *The Dream* is the fact that the camera operators for space scenes were astronauts, trained by IMAX cameramen who could not shoot the footage themselves. The IMAX production team spent the better part of a year training 14 astronauts in use of the IMAX camera, which is considerably more complex than the 16 millimeter and TV cameras used on earlier space missions. Weighing about 80 pounds on Earth, but nothing in space, the camera is nonetheless bulky and awkward to handle. As might be expected, however, the astronauts proved to be as competent in operating the camera as crews with years of experience.

NASA, in line with its charter to disseminate space program information as widely as possible, arranged to fly the camera on three 1984 Shuttle missions. The astronauts impressed their trainers

At work in the "office" of *Challenger* on Shuttle Flight 41-D are Commander Henry Hartsfield (left) and Pilot Michael Coats.



The schoolbus-size Long Duration Exposure Facility is released into space by *Challenger's* remote manipulator arm.

On Flight 41-D, the Lockheed-built flexible solar array is being extended to its 105-foot length.

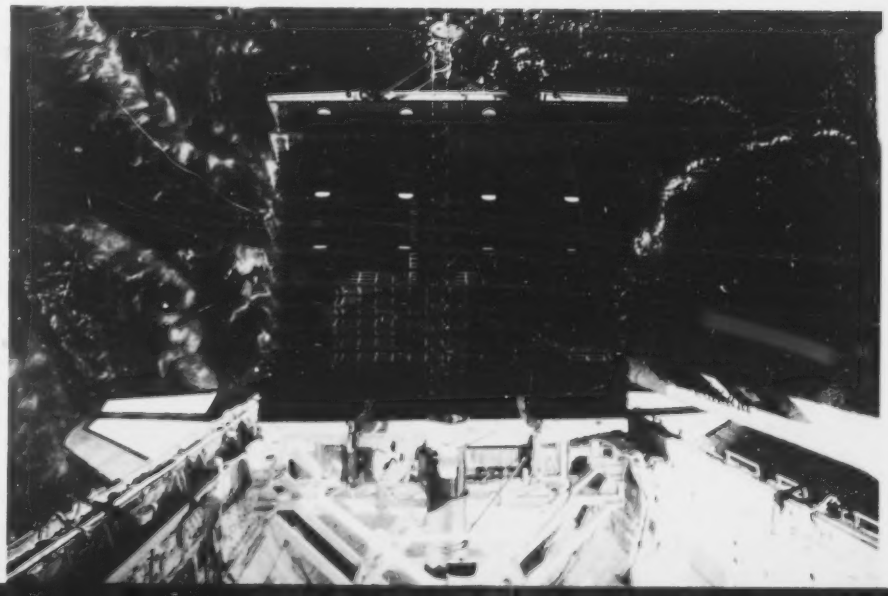
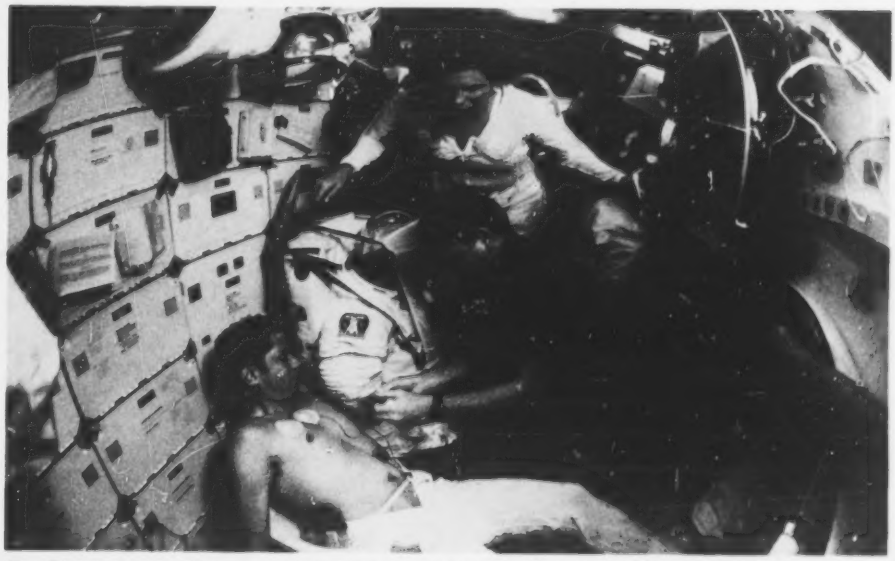


Photo credits: Threshold Corporation, Smithsonian Institution and Lockheed Corporation

Commander Hartsfield and Mission Specialists Mike Mullane and Steven Hawley, secured by restraints, sleep after a busy day on Flight 41-D.

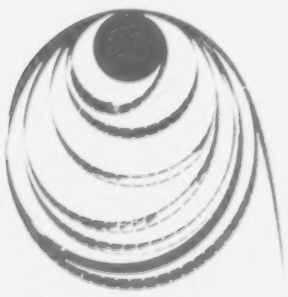


On Flight 41-G, Pilot Jon McBride helps Mission Specialist David Leestma don the liquid cooling space suit undergarment in preparation for a space walk, while Mission Specialist Kathy Sullivan floats above.

Leestma and Sullivan conduct a successful demonstration of the capability for refueling satellites in orbit.

with their abilities to solve the few technical problems that occurred and to make decisions as to which of four available lenses should be used for a specific scene; the camera was equipped with a 30 millimeter "fisheye" lens, a 40 millimeter normal lens, a 100 millimeter telephoto and a 250 millimeter telephoto. The IMAX production team provided a list of shots to be taken, but many of the sequences that wound up in the edited film resulted from astronaut initiatives. Remarkably, about one-fourth of all the footage shot appears in the final version; according to producer Ferguson, it is not unusual for professional cameramen to shoot 15 feet of film for every foot used in the finished product.

The result of the cooperative NASM/NASA/Lockheed/IMAX effort is a 37-minute presentation, narrated by Walter Cronkite, that takes the viewer along on a Shuttle mission—actually a composite of three missions—with startling realism. Among highlights are views of Earth from orbit; deployment of the huge Long Duration Exposure Facility intended to study the effects on a variety of materials of prolonged exposure to microgravity and vacuum conditions; extension of a 105-foot Lockheed-built flexible solar array that folds into a package only seven inches thick; and the historic retrieval and repair of the Solar Max spacecraft. A scene that particularly gripped previewers is an eerie view of astronauts sleeping, their bodies restrained by straps but their arms outstretched and floating. These and other highlights are shown in the accompanying photos.



THE YOUNG ASTRONAUTS

By ELLEN I. KELLY

More than 60,000 young Americans, many of them veterans of high tech video games and futuristic fiction, have become official participants in the U.S. space program as members of some 2,500 Young Astronaut chapters in schools and community groups across the country. One of their number, says the Young Astronaut Council, will eventually be the first young person to fly on the Shuttle. All of them will be stimulated by space-oriented math and science curricula, field trips to museums, manufacturing plants and space facilities, and national contests and events.

Launched by President Reagan on October 17, 1984 as a private sector initiative, the Young Astronaut Program has soared. More than 48,000 letters from students, teachers and parents reflect the wave of youth enthusiasm for space. As one 11-year-old wrote when she saw a newspaper article about the Program, "I said to myself, this is my chance . . . I have waited and waited, studied and studied." Another wanted to join because "I've always been interested in the Shuttle, astronomy, planets, stars, you know, SPACE in general."

The idea for the Young Astronauts was conceived by syndicated columnist Jack Anderson, who sold President Reagan on its merits in a 1983 meeting in the Oval Office. In discussing the "acute problem of preparing our kids for the future," Anderson said, the President embraced the idea of using the space program as a motivation for students to excel in math and science. After a year of evaluation by NASA's Special Task Force on Educational Innovation, the President announced the formation of the Young Astronaut Council in June 1984. Fifty pilot schools, selected from another White House private sector initiative program called Partnerships in

Education, tested curriculum materials and responded enthusiastically. Since the official launching, the number of chapters has steadily increased. According to Wendell Butler, Executive Director of the Young Astronaut Council, the Council hopes to have chapters in all 75,000 schools in the nation in two to three years, with a total membership of two to three million.

"Our goal is to establish a quality curriculum that will impact kids," Butler said. "We are trying to do something about the decline in math and science education in the U.S." A recent University of Northern Illinois study revealed that 90 percent of all high school graduates in the U.S. are scientifically and technologically illiterate, he said. Less than one-third of U.S. school districts require more than one year of math and science, compared to four to six-year requirements in the Soviet Union and Japan.

Anna J. Harrison, chairman of the American Association for the Advancement of Science, has said that one cause of the crisis is that U.S. educational reaction to the Soviet launch of Sputnik in 1957 aimed only for the top 10 percent of students, to produce more and better engineers and scientists. "It's our feeling that the U.S. can't continue to be run by the top 10 percent," Butler said. "That's why we want to excite the imagination of the other 90 percent through the Young Astronaut Program."

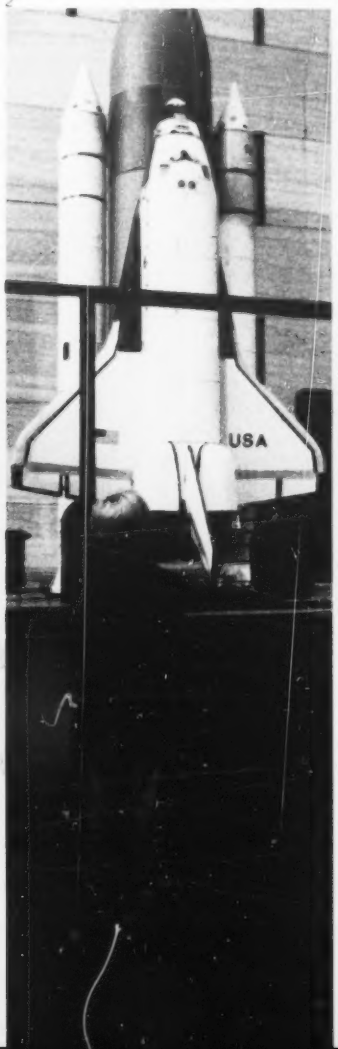
It's easy to start a chapter: sign up a group of five to 30 youngsters (grades first through ninth) and pay a $20 membership fee. Most chapters are classroom groups led by math and science teachers; more than 1,500 students lack access to a chapter are Satellite members. They receive all the materials and are eligible for all contests. A special drawing from the Satellite membership to select a youngster to attend Space Camp in Huntsville, Alabama took place this summer.

Curriculum materials are distributed at least four times during the school year. So far, they have consisted of large posters with suggested exercises and activities listed on the back for each age group. The chapters are divided into three levels: Trainees (Grades 1-3); Pilots (Grades 4-6); and Commanders (Grades 7-9). Each level contains three steps of progression, based on classroom performance and participation in chapter activities. Executive Director Butler says there are plans for handbooks in three to four years, possibly with accompanying merit badge requirements. Other future plans include a national jamboree, the formation of an international council for chapters in foreign countries and a contest for the best letter to a Young Cosmonaut.

In addition to the curriculum packs, the Young Astronaut Council provides a Chapter Leader's Handbook, which contains bibliographies, tips for planning field trips, contest ideas, and other reference materials. Each member receives a certificate. Butler said the Council has plans to fly on a Shuttle mission the die used to emboss the certificates.

Although the Council provides guidelines to the chapters, Butler said, "we adhere to President Reagan's idea of decentralization." Local school districts and community groups are encouraged to participate, and chapters are free to pick their own names, such as "Starburst," or "Constellation." "We plan to work with existing groups as much as possible, including the Boy Scouts and Girl Scouts, to encourage participation in math and science," Butler added.

Recently the Council organized a contest to design the official Young Astronaut flag. The winner, sixth grader Carey Ann



1. At a White House ceremony attended by students, teachers and representatives of government, industry and the educational community, President Reagan officially launched the Young Astronaut Program in October 1984. Columnist Jack Anderson, chairman of the Young Astronaut Council, is second from left.

2. and 3. Newly-initiated Young Astronauts were given a tour of the National Air and Space Museum. The Young Astronaut Program draws upon the excitement and promise of space to inspire student interest in science and technology and improve their competence in mathematics and related subjects.

4

5

4. and 5. Young Astronaut Executive Director Wendell Butler (left) leads a group of youngsters on a trip to Kennedy Space Center; holding a prototype of the Coleco Cabbage Patch doll, singer John Denver poses with some Young Astronauts.

Hazlett from Wentzville, Missouri, won a trip with her parents and teacher to the June Shuttle launch. Another event sponsored by the Council this summer was a link between the American Radio Relay League and Young Astronaut chapters for communication by "ham" radio with the crew of a Shuttle mission.

As a private sector initiative, the program depends solely on corporate/private contributions for funding. Current sponsors include Martin Marietta Aerospace, McDonnell Douglas Corp., Rockwell International, Adidas, CBS Television, Coleco, Commodore Computers, Group W Television, Marvel Productions, Pepsi-Cola USA, Quaker Oats, Safeway Stores, Tymnet and Xerox. Each has committed substantially, some in excess of $250,000 over three years in cash, services and materials. "The program wouldn't be possible without the sponsors," Butler says. "But we don't see these contributions as gifts. They are mutually beneficial, especially for the aerospace industry . . . these kids are their future."

Martin Marietta has funded two curriculum packages and supplied model rocket kits as the spring 1985 curriculum activity package. According to Butler, this is the type of project that motivates the students. "One chapter went so far as to design insect payloads to be launched with the rocket," he said. Additionally, Martin Marietta is contributing staff time and computer hardware to aid the Council in setting up a system for managing its rapidly growing records.

Tymnet, a subsidiary of McDonnell Douglas, has donated space in a data bank for Astronet, a computer service available to all chapters that provides updates on the space program, as well as supplementary exercises. "The Young Astronauts will give the aerospace industry a constituency of millions of kids who believe in space," says program initiator Jack Anderson.

Corporations outside the aerospace industry can benefit from sponsorship, Butler says, because the Young Astronauts has high visibility. Already, the Council has been deluged with requests to use the Young Astronaut logo for commercial purposes. Several major agreements have been reached that will provide royalties to the Young Astronauts, in addition to the $250,000 each corporate sponsor is committed to donate.

One major undertaking is the CBS cartoon series "The Young Astronauts," which will premiere on October 26. Produced by Marvel Productions, the animated series is set in the year 2015, and will chronicle the events aboard the Space Vessel *Courageous*. The 30 crew members include the Hampton family; the Hampton parents are fictional products of the Young Astronaut Program of the 1980s. The Council is working closely with Marvel to ensure that the scripts are scientifically accurate. A Marvel comic book about the series will be out in October.

The Young Astronaut logo will be seen on a forthcoming Adidas Young Astronaut line of children's sportswear, on Quaker Oats cereal boxes, on special edition Pepsi cans, and on Coleco Young Astronaut Cabbage Patch dolls. One line of dolls, Butler says, will be dressed in space suits and another will carry miniature passports. Other "toys-that-teach" may be developed from the cartoon series, he said. The logo has already appeared on Safeway store bags, generating over 20,000 responses.

In addition to financial sponsorships, a number of professional and non-profit groups have contributed time and expertise. Groups such as NASA, the National Space Institute, the Smithsonian Institution, the National Science Foundation, the U.S. Department of Education, the National Mathematics and Science Teachers Associations and the National School Boards Association serve as advisors for the program. An Educational Technical Advisory Board, consisting of 30 representatives from the space and education communities, reviews all materials developed by the Council before they are sent to the chapters.

The Young Astronaut Council has a staff of 15, eight of whom are on loan to the program from various government agencies and the private sector. The Council's Executive Committee is composed of Jack Anderson, chairman; Hugh Downs, vice chairman; and Harold Burson, president of the Burson Marsteller public relations agency, secretary. Information about the Young Astronauts can be obtained from the Young Astronaut Council, 1211 Connecticut Ave., N.W., Suite 800, Washington, D.C. 20005, (202) 682-1984.

"What we are talking about," says Jack Anderson, "is moving an entire generation from automobiles to high tech. The challenge is much greater than when we moved from the horse and buggy era to automobiles, and our kids have less time to prepare. We must stimulate them to go out and study to meet the challenge."

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